

## Equities

16 November 2010 | 21 pages

# World Energy and Carbon Outlook

## Climate Change Targets Challenging Under OECD/IEA Projections

- **Cautious Climate Action; Continued Fossil Fuel Demand** — The OECD/IEA “*World Energy Outlook 2010*” looks at the energy outlook to 2035, under three scenarios for reducing global greenhouse gas emissions. In the “middle” case, (perhaps the most likely), greenhouse gas levels remain above 450ppm, and fossil fuel demand, particularly from non-OECD countries, remains strong to 2035.
- **Three Scenarios to 2035** — The IEA’s “Current Policies” Scenario assumes policies that have been implemented. The New Policies Scenario assumes cautious implementation of policies and pledges currently announced. The 450 Scenario means limiting atmospheric greenhouse gas concentrations to 450 parts per million, a level often considered consistent with limiting warming to 2°C.
- **The “New Policies” (NP) Scenario Most Likely** — 450ppm may be required for the 2°C objective, but looks challenging. The intermediate NP Scenario currently looks more likely. We would need to see greater coordinated international action to believe 450ppm will be achieved. The IEA illustrates the extra effort required to meet 450ppm, by country/region and by technology (Figure 4 to Figure 7).
- **IEA Scenarios Fall Short of the Potsdam Carbon “Budget” Approach** — Potsdam Institute research suggests that, for different probabilities of limiting warming to 2°C, only 25% to 50% of proven economically recoverable fossil fuel reserves can be used. Policy outcomes to achieve this scenario appear unlikely. [See “*Australian Equities – Pricing Carbon Risk: Valuation Scenarios for Fossil Fuel Equities*”, <https://www.citigroupgeo.com/pdf/SAU09810.pdf>, 27 September 2010.]
- **Implications for Fossil Fuel Demand** — In all three IEA scenarios, fossil fuels dominate the energy mix to 2035 (Figure 10). In the NP Scenario, coal fired electricity generation continues to grow to 2035 and remains the dominant generation source, though gas grows faster (Figure 11).
- **Coal & LNG Demand Persists** — In the NP Scenario, world primary coal demand grows to around 2020, then remains flat (Figure 12). OECD demand falls as older electricity plants are retired. Growth occurs in non-OECD economies including India (Figure 13), with Chinese demand flattening (Figure 18). Gas demand would grow to 2035 (Figure 23), and LNG sales from Australia would grow from ~22 bcm in 2008 to ~87 bcm in 2035 (Figure 24).
- **450ppm a Risk to Coal** — Under the 450 Scenario, coal demand would fall after 2020, and CCS would play an increasing role (Figure 15, Figure 16). Accelerated signs of coordinated global action could pose a risk to coal.
- **Australian Carbon Policy Expectations** — Great uncertainty exists. Our “best guess” is a fixed carbon price (~\$20-25/t initially) for the generation sector, with the scheme to be broadened when more international clarity emerges.

See Appendix A-1 for Analyst Certification, Important Disclosures and non-US research analyst disclosures.

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## World Energy Outlook 2010 – IEA / OECD

The OECD / International Energy Agency released its report, “*World Energy Outlook 2010*”, on 9 November. The report looks at the outlook for energy to 2035, taking into account various scenarios for addressing global greenhouse gas emissions.

We reviewed the report to:

- understand the IEA’s scenarios on the prospects of moving to a carbon constrained world; and
- to understand the IEA’s assumptions for fossil fuel demand, particularly coal and LNG, under its various scenarios.

This provides a perspective for the outlook for fossil fuels, and on the outlook for global carbon constraints more broadly.

Where coal is discussed in this report, it generally relates to energy use, and excludes coal for steelmaking.

## The IEA’s Three Scenarios

WEO-2010 presents three scenarios for future government policies relating to carbon constraints and the energy sector.

The “New Policies Scenario” might be considered the “most likely” case, though it falls well short of the “450ppm Scenario” believed necessary to limit warming to 2°C.

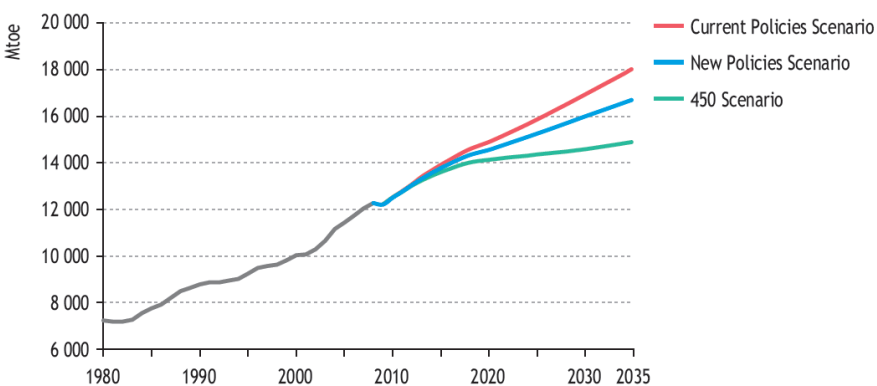
- **Current Policies Scenario** - A baseline in which only policies already formally adopted and implemented are taken into account.
- **New Policies Scenario** - Assumes introduction (albeit cautiously) of new measures to implement broad policy commitments that have already been announced, including national pledges to reduce greenhouse-gas emissions and, in certain countries, plans to phase out fossil energy subsidies.
- **450 Scenario** - An energy pathway consistent with the goal of limiting the global increase in average temperature to 2°C, requiring the atmospheric concentration of greenhouse gases to be limited to around 450 parts per million (ppm) of carbon dioxide equivalent (CO<sub>2</sub>-eq or CO<sub>2</sub>e). This scenario demonstrates the scale of the challenge to achieve the 450ppm target.

The main focus of the report is on the “New Policies Scenario”.

More detail on the assumptions behind the New Policies and 450 Scenarios are given on Page 17.

Energy demand grows in all scenarios, despite different levels of energy efficiency measures.

Figure 1. World Primary Energy Demand by Scenario



Source: IEA – World Energy Outlook 2010

\*Note: Mtoe = million tonnes of oil equivalent

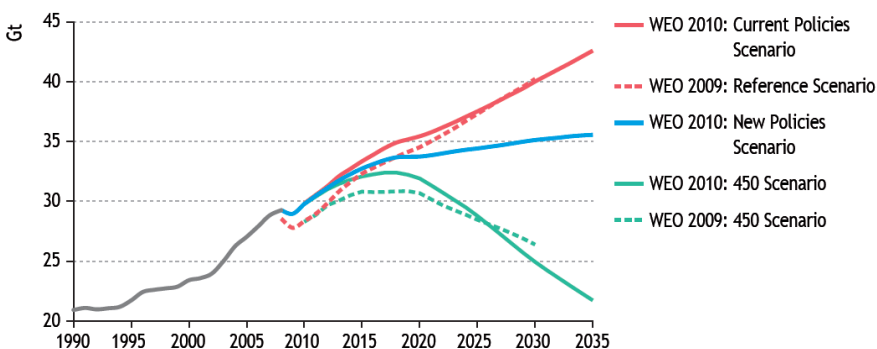
### Current Commitments Mean Emissions Well Above 450ppm

Figure 2 shows energy related emissions under the three scenarios.

This shows that even if policy commitments made to date are implemented (ie the New Policies Scenario), substantial additional cuts would be required to meet the 450ppm target.

Even if current policy commitments were implemented (the “New Policies Scenario”), emissions would still grow.

Figure 2. World Energy-Related CO<sub>2</sub> Emissions by Scenario



Source: IEA – World Energy Outlook 2010

### Cost to Achieve 450ppm

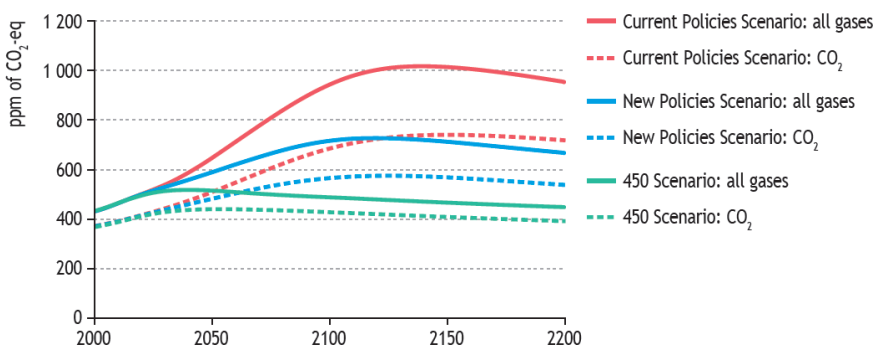
- Additional spending of US\$11.6 trillion is required over the period 2010 to 2030 to achieve the 450 Scenario, compared with the Current Policies Scenario. This increases to US\$18t over the longer period 2010 to 2035.
- Additional spending is estimated at US\$13.5t over the 2010 to 2035 period to achieve 450ppm, compared with the New Policies Scenario (ie spending above policy commitments made to date).
- This shows that substantial additional funds will be required, compared with current policy commitments, to achieve 450ppm.

**Changes Post Copenhagen** – The trajectory to 2020 is slightly higher than in last year's *WEO-2009* report, which started from a lower baseline and assumed stronger policy action before 2020. Emissions reduction expectations were downgraded after the December 2009 Copenhagen meeting. Therefore, a faster decline is now required after 2020 to achieve the 450ppm target. (Figure 2)

The New Policies Scenario shows a long-term path towards an atmospheric concentration of CO<sub>2e</sub> of around 650ppm. (Figure 3)

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**Figure 3. Greenhouse-Gas Concentration Trajectories by Scenario**



Source: IEA – World Energy Outlook 2010

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## What More is Needed to Meet a 450 ppm Target?

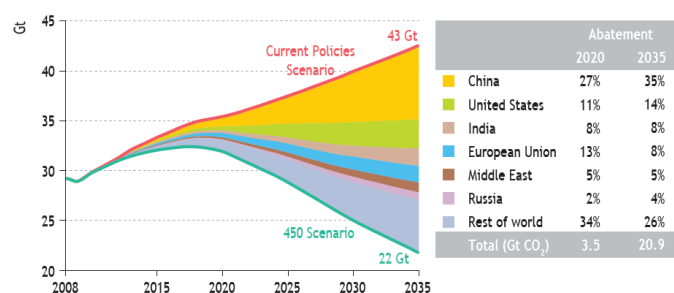
Under the 450ppm Scenario, world energy-related CO<sub>2</sub> emissions would peak before 2020. This scenario requires action well beyond current policies or current commitments.

- Figure 4 and Figure 5 show the difference in energy related emissions under the 450ppm Scenario compared with the Current Policies Scenario.
- Figure 6 and Figure 7 show required reductions to achieve 450ppm, compared with the New Policies Scenario.

In both cases, substantial additional change is required particularly in China and the US, compared with their current policies / commitments.

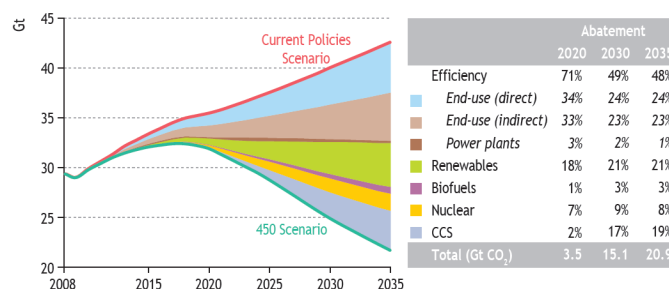
Globally, energy efficiency, renewable energy and carbon capture and storage (CCS) are key requirements. First, cheaper technologies are adopted (eg energy efficiency), and more expensive options are taken up later (eg nuclear, CCS).

**Figure 4. World Energy-Related CO<sub>2</sub> Emission Savings by Region in the 450 Scenario Compared with the Current Policies Scenario**



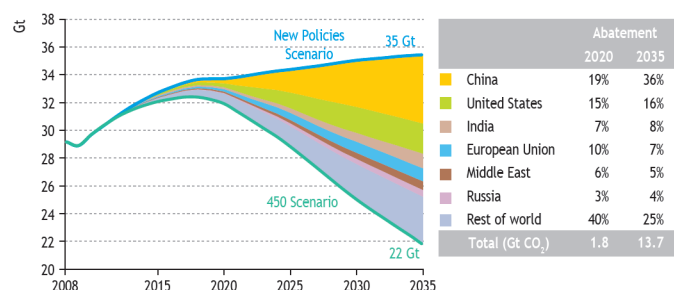
Source: IEA – World Energy Outlook 2010

**Figure 5. World Energy-Related CO<sub>2</sub> Emission Savings by Policy Measure in the 450 Scenario Compared with the Current Policies Scenario**



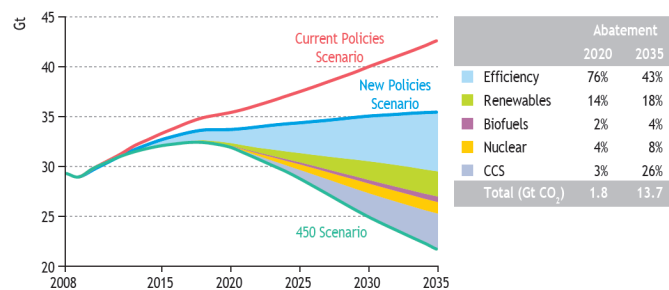
Source: IEA – World Energy Outlook 2010

**Figure 6. World Energy-Related CO<sub>2</sub> Emission Savings by Region in the 450 Scenario Compared with the New Policies Scenario**



Source: IEA – World Energy Outlook 2010

**Figure 7. World Energy-Related CO<sub>2</sub> Emission Savings by Policy Measure in the 450 Scenario Compared with the New Policies Scenario**



Source: IEA – World Energy Outlook 2010

## World Fuel Demand for Energy

To achieve 450ppm, coal demand peaks before 2020 – though this requires policy action far beyond current commitments.

On current commitments, coal demand would rise then flatten, not fall.

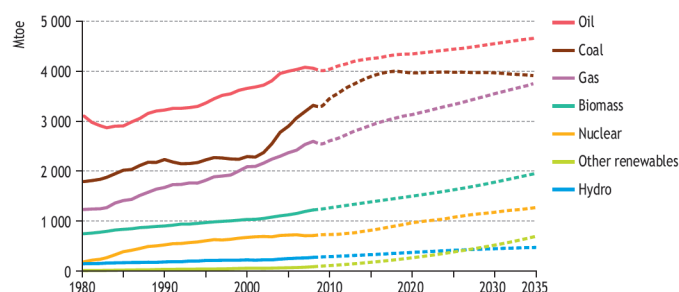
Figure 8 and Figure 9 show energy demand by fuel under the New Policies Scenario and 450ppm Scenario.

Energy demand includes fuel for electricity generation, and also direct energy demand by industry.

Under the New Policies Scenario, demand for each fuel source increases over the outlook period, with coal demand peaking around 2017 and then flattening.

In the 450ppm Scenario, coal and oil demand peak before 2020, with coal falling significantly by 2035. Gas demand peaks around 2025 to 2030.

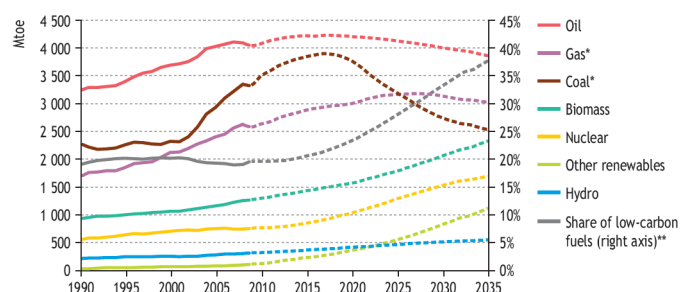
Figure 8. World Primary Energy Demand by Fuel in the New Policies Scenario



Source: IEA – World Energy Outlook 2010

\*Note: Mtoe = million tonnes of oil equivalent

Figure 9. World Primary Energy Demand by Fuel in the 450 Scenario



\*Includes CCS. \*\*Excludes CCS.

Source: IEA – World Energy Outlook 2010

\*Note: Share of low-carbon fuels include nuclear, CCS-fitted plants, hydro & other renewables

**In the New Policies Scenario, fossil fuel volumes grow to 2035, despite their share of energy demand falling.**

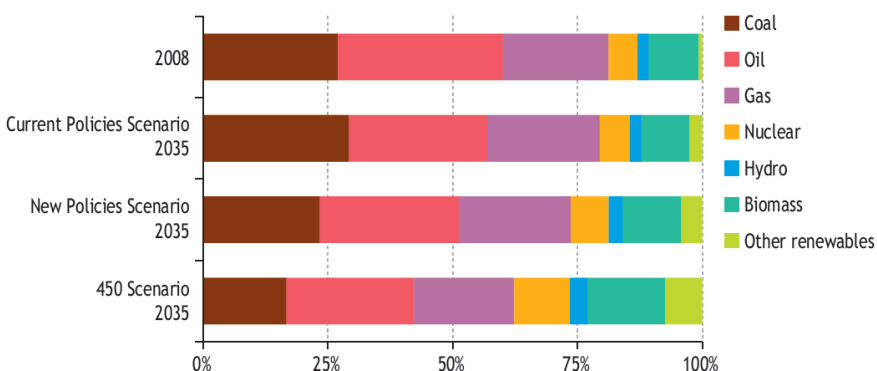
Under this Scenario, fossil fuels (oil, coal and natural gas) account for 53% of the energy increase from 2008 to 2035. Their share of global energy consumption falls from 81% in 2008 to 74% in 2035.

This is despite various pressures that help to restrain demand growth, including:

- Rising fossil-energy prices to end-users, resulting from upward price pressures on international markets and increasing costs of carbon;
- Policies to encourage energy savings and switching to low-carbon energy sources.

Fossil fuels remain the dominant energy source in 2035 in all three scenarios.

Figure 10. Shares of Energy Sources in World Primary Demand by Scenario



Source: IEA – World Energy Outlook 2010

## Electricity Sector by Fuel Type

Electricity is the major component of energy demand.

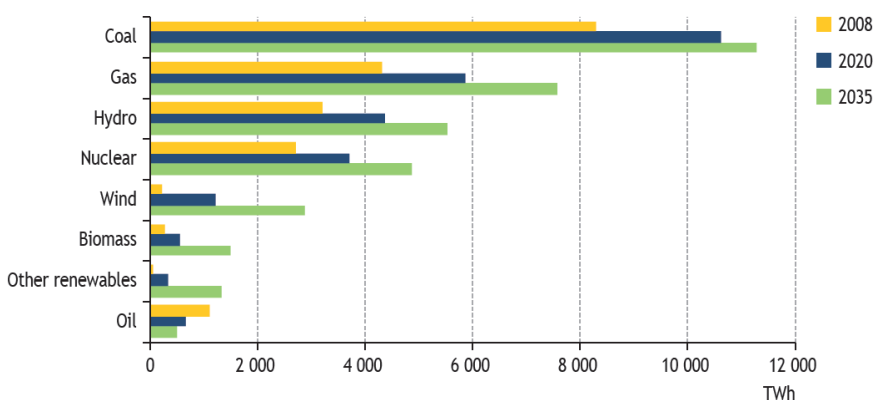
In the New Policies scenario, coal continues to be the main source of electricity production. Coal generation output increases, though its share of the world generation mix declines from 41% in 2008 to 32% by 2035. (Figure 11)

To the extent that power generation becomes more efficient, coal use would increase more slowly than coal related power output.

Electricity production from natural gas, hydro and nuclear all grow in absolute terms, but remain constant in percentage terms.

The share of generation from wind, biomass, and other renewables increases from 3% in 2008 to 16% by 2035.

Figure 11. World Electricity Generation by Type in the New Policies Scenario



Source: IEA – World Energy Outlook 2010

In this Scenario, electricity from coal increases to 2035, including growth beyond 2020.

However, overall energy demand for coal flattens beyond 2020 (Figure 8).

This divergence may be due to improved generation efficiency (ie more megawatt-hours per unit of coal) and because Chinese industrial (non generation) demand for coal falls (see Page 13).



## Australia's Coal Exports

Global climate change policy has implications for coal demand. This is particularly relevant to Australian investors, given Australia's large coal exports. The strength of coal demand will impact both listed equities, and the Australian economy more broadly.

**The discussion here refers to coal for energy applications, and excludes coal for steelmaking.**

Citi's research report "*Risk On - But Fundamentals are Important: Commodity Outlook*" by Alan Heap (8 November 2010, <https://www.citigroupgeo.com/pdf/SGL66793.pdf>) includes tables of the supply demand balance for thermal coal and for coking coal. These show forecasts for:

- Australian exports of thermal coal 160mt in 2011, 212mt in 2015;
- Australian exports of coking (metallurgical) coal 160mt in 2011, 192mt in 2015.

## Coal Energy-Related Demand

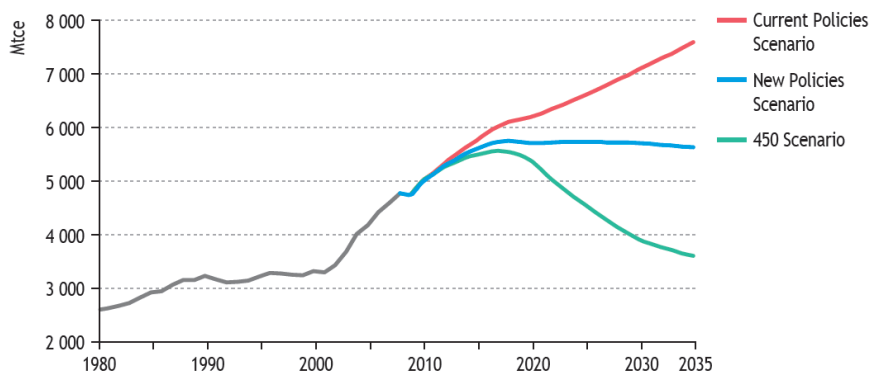
Under the Current Policies Scenario, coal demand continues to grow at least until 2035.

In the New Policies Scenario, demand for coal increases by around 20% between 2008 and 2035, but almost all the growth occurs before 2020.

To achieve 450ppm, coal demand peaks before 2020.

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**Figure 12. World Primary Coal\* Demand by Scenario**



\*Includes hard coal (steam and coking coal), brown coal (lignite) and peat.

Source: IEA – World Energy Outlook 2010

\*Note: Mtce = million tonnes of coal equivalent

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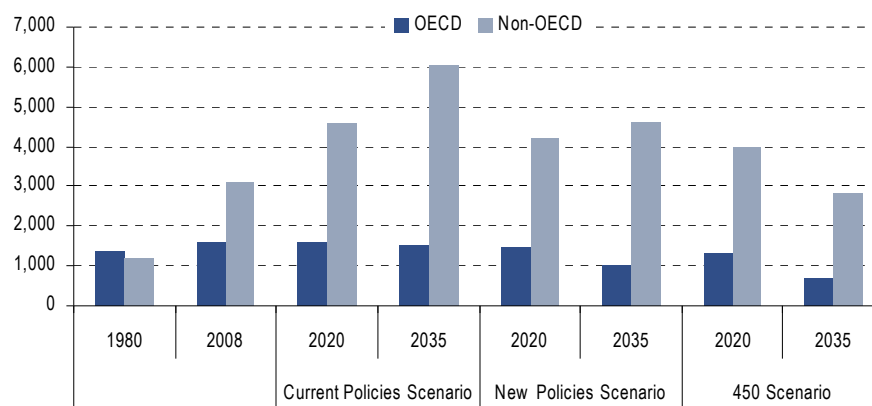
In all three scenarios, OECD coal use falls between 2008 and 2035, as developed countries decarbonise their electricity generation mix. Coal demand does not return to the peak levels seen before the 2008 global financial crisis. (Figure 13)

In the New Policies Scenario:

- **OECD coal demand declines** on average by 1.7% per year. It accounts for less than 20% of global coal demand by 2035, compared with one-third today.
- **Non-OECD countries account for all the growth** in global coal demand. Their share of world demand grows from 66% today to 82% by 2035. (Figure 14)

Non-OECD coal demand only falls in 450 ppm Scenario

Figure 13. World Primary Coal Demand by Region and Scenario (Mtce)



Source: IEA – World Energy Outlook 2010, Citi Investment Research and Analysis

Figure 14. World Primary Coal Demand by OECD / Non-OECD and Scenario (Mtce)

			New Policies Scenario		Current Policies Scenario		450 Scenario	
	1980	2008	2020	2035	2020	2035	2020	2035
OECD	1 379	1 612	1 452	1 021	1 596	1 507	1 348	709
Non-OECD	1 181	3 124	4 213	4 600	4 557	6 037	3 998	2 856
<b>Total</b>	<b>2 560</b>	<b>4 736</b>	<b>5 665</b>	<b>5 621</b>	<b>6 153</b>	<b>7 544</b>	<b>5 347</b>	<b>3 566</b>
<i>Share of non-OECD</i>	46%	66%	74%	82%	74%	80%	75%	80%

Source: IEA – World Energy Outlook 2010

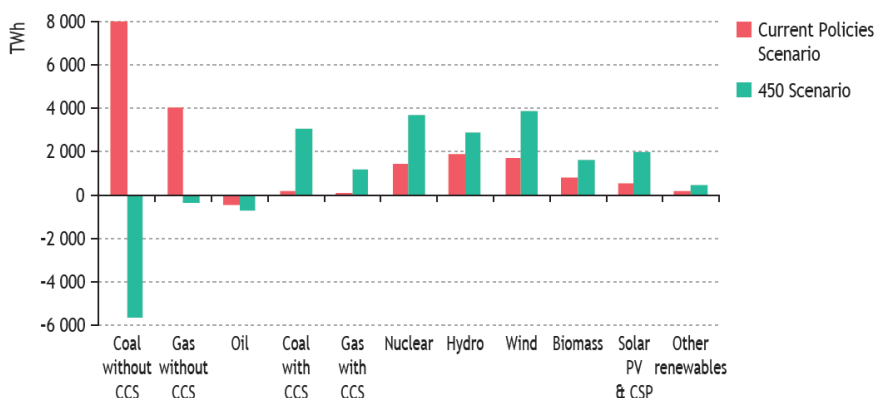
## Coal and CCS in Electricity Generation

In the Current Policies Scenario, coal generation without carbon capture and storage (CCS) doubles to 16,300 TWh.

Implementation of CCS at both coal and gas fired power stations is a key assumption in the 450ppm Scenario. (Figure 15)

Carbon Capture and Storage (CCS) is a key component of the 450ppm Scenario – for coal and gas plants.

Figure 15. Incremental World Electricity Generation by Fuel and Scenario, 2008-2035



Source: IEA – World Energy Outlook 2010

\*Note: 1 Terawatt-hour = 1 billion KWh

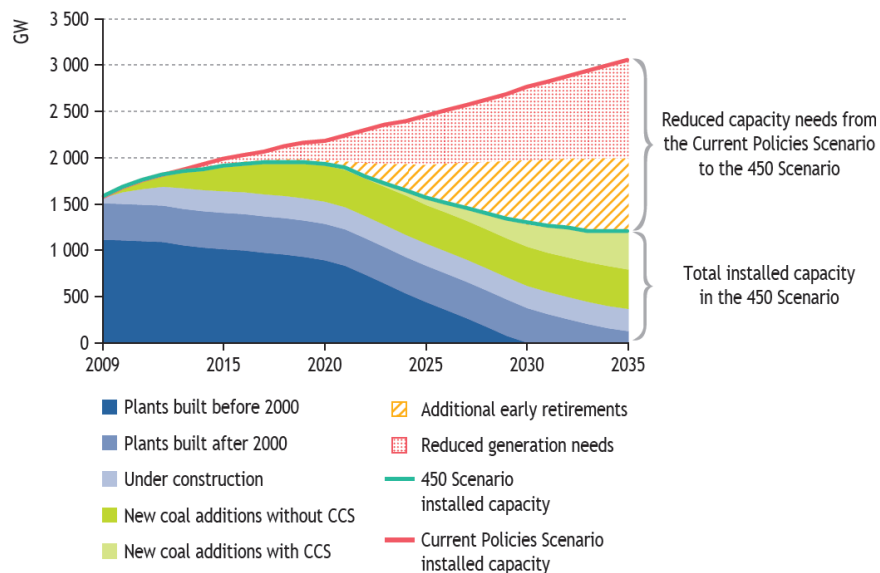
- By 2035, in the 450 Scenario, coal generation from plants without CCS falls. Coal with CCS reaches more than 3,000 TWh.
- Gas with CCS reaches around 1,000 TWh.
- More coal plants do have CCS than do not have CCS.

In the 450 Scenario, after 2020, introduction of carbon cap-and-trade systems in OECD+ and Other Major Economies prompts rapid retirement of older inefficient coal plants. Most existing plant is taken out of service by 2035. However, new coal plants are built, with and without CCS. (Figure 16)

Older coal plants are retired.

New plants are built, with and without CCS.

**Figure 16. World Installed Coal-Fired Generation Capacity in the 450 Scenario Relative to the Current Policies Scenario**



Source: IEA – World Energy Outlook 2010

The number of CCS-fitted plants increases significantly. Many existing plants are retrofitted in order to remain economic and extend their lifetime.

Under the 450 Scenario, electricity generation from coal plants without CCS in 2035 falls by more than two-thirds, compared with today. Most of the drop occurs in OECD+ countries.

Coal generation increases only in countries that do not introduce cap-and-trade systems by the end of the projection period (ie. India).

## Coal Demand - China & India

Figure 12 and Figure 13 show that world coal demand varies significantly between the different scenarios.

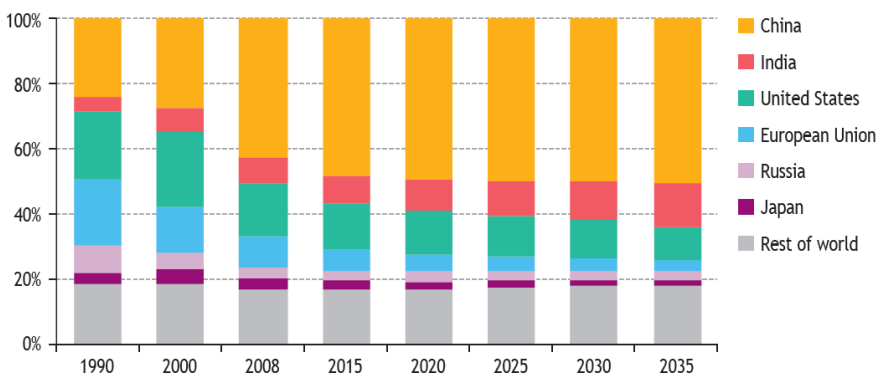
Given Australia's role as a major coal exporter, we have looked at the projections for China and India, which are significant players in world markets.

**Comments below focus on the New Policies Scenario, in which coal demand peaks before 2020, then flattens** (Figure 20).

Figure 17 shows how Chinese and Indian demand grows, offsetting modelled declines in the US and Europe. Detailed country-by-country projections are tabled in Figure 21.

India is the key component of coal growth.

Figure 17. Share of Key Regions in Global Primary Coal Demand in the New Policies Scenario



Source: IEA – World Energy Outlook 2010

### China

Coal demand in China grows by 2.7% per year to 2020 in the New Policies Scenario, and remains fairly stable through the rest of the projection period. Growth in coal for power generation continues, albeit at a slower pace than historically. This is offset by falling coal demand for industry, which peaks before 2020 and then declines. (Figure 18)

### India

Coal demand in India doubles from around 370 Mtce today to 780 Mtce by 2035 in the New Policies Scenario. More than half the increase is from the power sector, and another 38% of the increase is from the industrial sector. (Figure 19)

Despite this strong projected growth, coal's share of India's primary energy demand declines from 42% today to 39% by 2035. Coal loses market share to renewables, gas and nuclear for power generation.

Citi's research report "*Opportunities In Emerging Markets: Commodity Update*" by Alan Heap, 20 October 2010, expects coal to be a big winner from the Indian supercycle / urbanisation, with rising imports as domestic supply fails to keep pace with demand. (<https://www.citigroupgeo.com/pdf/SGL01966.pdf>)

Figure 18. China – Primary Coal Demand in the New Policies Scenario (Mtce)

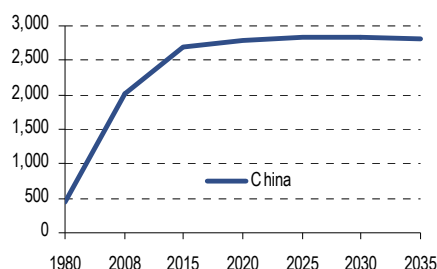


Figure 19. India – Primary Coal Demand in the New Policies Scenario (Mtce)

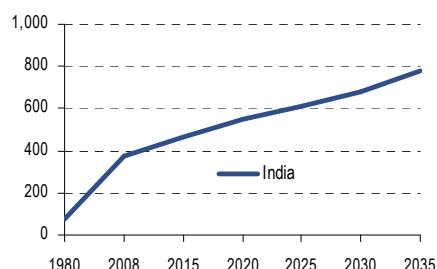
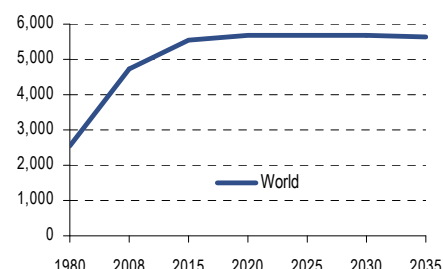


Figure 20. Global – Primary Coal Demand in the New Policies Scenario (Mtce)



Source: IEA, Citi Investment Research and Analysis  
\*Note: Mtce = million tonnes of coal equivalent

Figure 21. Primary Coal Demand by Region in the New Policies Scenario (Mtce)

	1980	2008	2015	2020	2025	2030	2035	2008-2035*
OECD	1 379	1 612	1 562	1 452	1 337	1 208	1 021	-1.7%
North America	571	828	827	789	740	681	596	-1.2%
United States	537	780	777	747	705	649	576	-1.1%
Europe	663	447	392	346	312	278	226	-2.5%
Pacific	145	337	342	318	285	249	199	-1.9%
Japan	85	162	161	146	125	106	82	-2.5%
Non-OECD	1 181	3 124	3 999	4 213	4 357	4 484	4 600	1.4%
E. Europe/Eurasia	517	325	324	305	304	296	290	-0.4%
Caspian	n.a.	47	57	59	60	57	56	0.7%
Russia	n.a.	167	170	163	163	159	158	-0.2%
Asia	572	2 601	3 458	3 687	3 830	3 958	4 081	1.7%
China	446	2 019	2 685	2 788	2 831	2 842	2 822	1.2%
India	75	373	467	551	609	682	781	2.8%
Indonesia	0	53	95	111	131	151	168	4.4%
Middle East	2	14	17	16	18	23	29	2.9%
Africa	74	149	151	159	161	164	160	0.3%
Latin America	16	35	49	46	43	43	40	0.6%
Brazil	8	20	28	24	21	21	20	0.2%
World	2 560	4 736	5 561	5 665	5 694	5 692	5 621	0.6%
European Union	n.a.	434	374	314	277	240	193	-3.0%

\* Compound average annual growth rate.

Source: IEA – World Energy Outlook 2010

\*Note: Mtce = million tonnes of coal equivalent

## Changes in Coal Demand

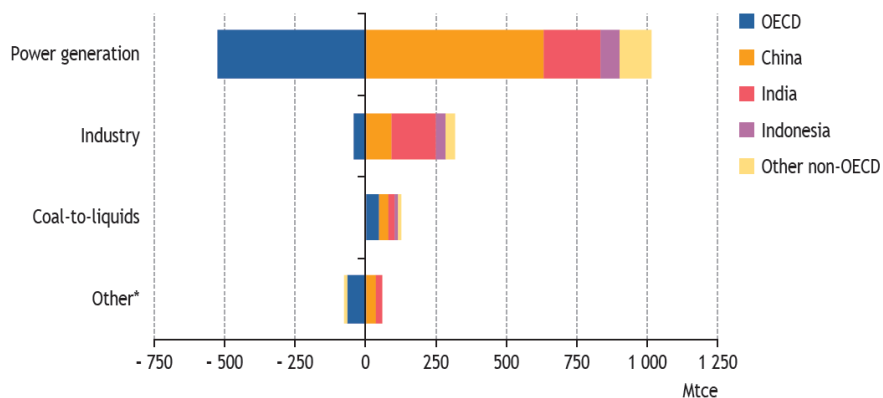
Over the 2008 to 2035 period, power generation accounts for almost 60% of the 885 Mtce increase in global coal demand. Another 30% comes from the industrial sector, particularly in India. (Figure 22)

**Figure 22. Change in Primary Coal Demand by Sector and Region (New Policies Scenario, 2008-2035)**

OECD coal demand for power generation falls.

Non-OECD demand grows, for power and industry.

Most Chinese growth is before 2020.  
Indian growth continues to 2035.



\* Includes other energy sector, transport, buildings, agriculture and non-energy use.

Source: IEA – World Energy Outlook 2010

\*Note: Mtce = million tonnes of coal equivalent

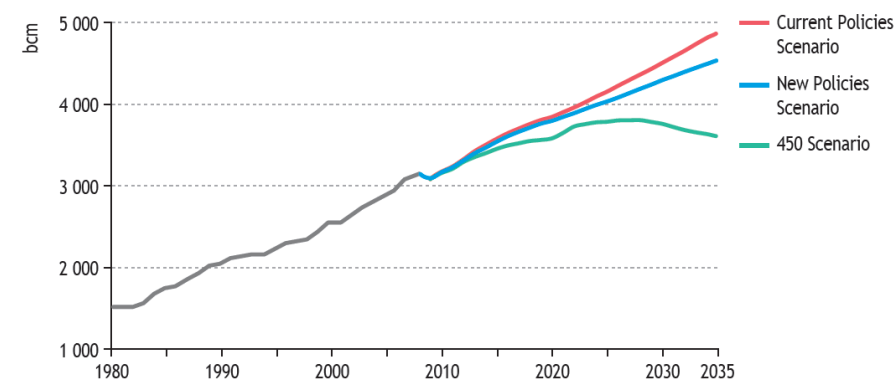
## Natural Gas Demand

We looked briefly at the IEA's gas demand projections, primarily due to Australia's role as an LNG exporter.

Global natural gas demand grows across the three scenarios.

After 2025, in the 450 Scenario, gas demand for energy falls slightly, as renewables and nuclear power increase.

Figure 23. World Primary Natural Gas Demand by Scenario

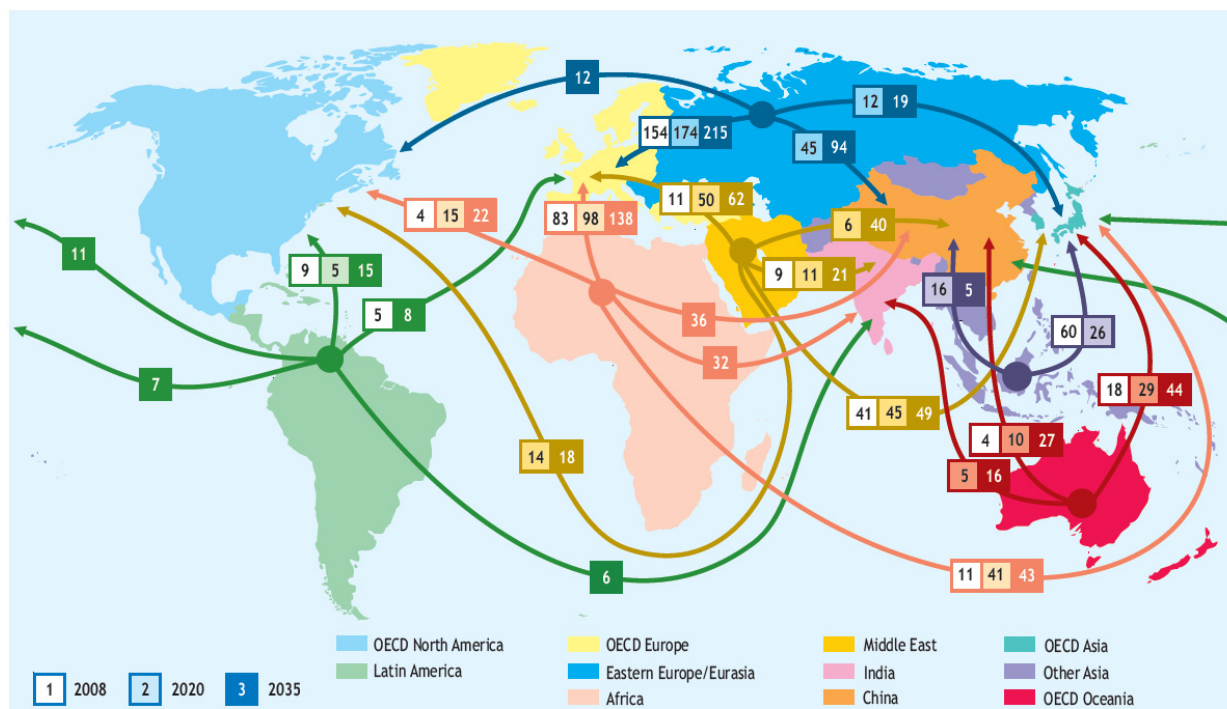


Source: IEA – World Energy Outlook 2010

\*Note: bcm = billion cubic metres

Gas sales from Australia are projected to rise under the New Policies Scenario from 22 billion cubic metres in 2008, to 44bcm in 2020 and 87bcm in 2035. (Figure 24)

Figure 24. Inter-Regional Natural Gas Net Trade Flows Between Major Regions in the New Policies Scenario (bcm)\*



The boundaries and names shown and the designations used on maps included in this publication do not imply official endorsement or acceptance by the IEA.

\* Only flows above 4 bcm are shown.

Source: IEA – World Energy Outlook 2010

\*Note: bcm = billion cubic metres



## IEA Scenario Details

### New Policies Scenario Assumptions

The New Policies Scenario takes account of the broad policy commitments and plans that have been announced by countries around the world, including:

- Cautious implementation of the Copenhagen Accord commitments by 2020.
- Continuation of the European Union Emissions Trading Scheme (EU ETS), and introduction of a cap-and-trade system in the rest of the OECD+ after 2020.
- Phase out of fossil-fuel consumption subsidies in all net-importing regions by 2020 (and, as in the Current Policies Scenario, in net-exporting regions where specific policies have already been introduced).
- Extension of nuclear plant lifetimes by 5 to 10 years with respect to the Current Policies Scenario, on a plant-by-plant basis.
- For 2020-2035, additional measures that maintain the pace of the global decline in carbon intensity — measured as emissions per dollar of gross domestic product, in purchasing power parity terms — established in the period 2008-2020.

These commitments are assumed to be implemented in a relatively cautious manner, reflecting their non-binding character and, in many cases, the uncertainty shrouding how they are to be put into effect.

**Figure 25. Principal Policy Assumptions by Scenario and Major Region, 2020**

	New Policies Scenario	450 Scenario
<b>OECD</b>		
United States	15% share of renewables in electricity generation; push for domestic supplies, including gas and biofuels.	17% reduction in greenhouse-gas emissions compared with 2005 (with access to international offset credits).
Japan	Implementation of the Basic Energy Plan.	25% reduction in greenhouse-gas emissions compared with 1990 (with access to international offset credits).
European Union	25% reduction in greenhouse-gas emissions compared with 1990 (including Emissions Trading Scheme).	30% reduction in greenhouse-gas emissions compared with 1990 (with access to international offset credits).
<b>Non-OECD</b>		
Russia	15% reduction in greenhouse-gas emissions compared with 1990.	25% reduction in greenhouse-gas emissions compared with 1990.
China	40% reduction in CO <sub>2</sub> intensity compared with 2005 (low-end of targeted range).	45% reduction in CO <sub>2</sub> intensity compared with 2005 (high-end of targeted range); 15% share of renewables and nuclear power in primary demand.
India	20% reduction in CO <sub>2</sub> intensity compared with 2005.	25% reduction in CO <sub>2</sub> intensity compared with 2005.
Brazil	36% reduction in greenhouse-gas emissions compared with business-as-usual.	39% reduction in greenhouse-gas emissions compared with business-as-usual.

Source: IEA – World Energy Outlook 2010

## 450 Scenario Assumptions

The 450 Scenario takes into account all policies and measures included in the New Policies scenario, some of which are assumed to be substantially strengthened and extended, plus the following:

- Implementation by 2020 of the high-end of the range of the Copenhagen Accord commitments where they are expressed as ranges.
- Cap-and-trade systems in the power and industry sectors, from 2013 in OECD + countries and after 2020 in Other Major Economies (OME).
- International sectoral agreements for the iron and steel, and the cement industries.
- International agreements on fuel-economy standards for passenger light-duty vehicles (PLDVs), aviation and shipping.
- National policies and measures, such as efficiency standards for buildings and labelling of appliances.
- The complete phase-out of fossil-fuel consumption subsidies in all net-importing regions by 2020 (at the latest) and in all net-exporting regions by 2035 (at the latest), except for the Middle East where it is assumed that the average subsidisation rate declines to 20% by 2035.
- Extension of nuclear plant lifetimes by 5 to 10 years with respect to the New Policies scenario, on a plant-by-plant basis.

## Appendix A-1

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